Claims

1. A signal processing system for processing a plurality of multi-element data encoding vectors, the system:

- having means for deriving the data encoding vectors from input signals;

- being arranged to process the data encoding vectors using a Gaussian Mixture Model (GMM) based Hidden Markov Model (HMM), the GMM based HMM having at least one class mean vector having multiple elements;

- being arranged to process the elements of the class mean vector(s) by an iterative optimisation procedure;

characterised in that the system is also arranged to scale the elements of the class mean vector(s) during the optimisation procedure to provide for the class mean vector(s) to have constant modulus at each iteration, and to normalise the data encoding vectors input to the GMM based HMM.

2. A system as claimed in claim 1 wherein the GMM based HMM has a covariance matrix, the elements of which remain constrained during the optimisation procedure such that the matrix is isotropic and diagonal, and the value of the non zero diagonal elements remain constant throughout the optimisation procedure.

3. A system as claimed in claim 1 or claim 2 wherein prior class probabilities associated with the GMM based HMM are constrained to be equal, and to remain unchanged throughout the optimisation procedure.

4. A system as claimed in any of the above claims wherein the data encoding vectors are normalised such that the vectors have equal moduli.

5. A system as claimed in claim 4 wherein the modulus of each data encoding vector is independent of the overall spectral power in the vector.

6. A system as claimed in claim 4 or claim 5 wherein elements forming spectral coefficients of a data encoding vector are arranged to be individually proportional to the square root of the power in their corresponding spectral band divided by the square root of the overall power contained in spectral bands represented in the vector.

7. A system as claimed in any of claims 4 to 6 wherein the system is arranged to add at least one additional element to each data encoding vector, wherein the added element(s) encode the overall power contained in spectral bands represented in the vector.

8. A system as claimed in claim 7 wherein the system is arranged to add two elements to each data encoding vector to represent the overall power in spectral bands, these two elements arranged such that the sum of their squares is a constant across all data encoding vectors that represent the spectrum of the input signal.

9. A system as claimed in any of claims 1 to 8 wherein the GMM based HMM provides the observation probabilities for a higher level HMM.

10. A system as claimed in any of claims 1 to 9 wherein the derivation of the data encoding vectors from the input signal involves the use of a low level GMM, whereby this low level GMM provides the data encoding vectors to the GMM based HMM that comprise elements derived from the low level GMM's posterior probabilities.

11. A system as claimed in claim 10 wherein elements of the data encoding vectors input from the low level GMM to the GMM based HMM are proportional to the square root of posterior probabilities of the low level GMM.

12. A system as claimed in claim 10 wherein elements of the data encoding vectors input from the low level GMM to the GMM based HMM are proportional to posterior probabilities of the low level GMM.

13. A system as claimed in any of claims 9 to 12 wherein the constant values for the modulus of each of the class mean vectors may be different at each level.

14. A signal processing system for processing a plurality of multi-element data encoding vectors, the system:

- having means for deriving the data encoding vectors from input signals;

- being arranged to process the data encoding vectors using a Gaussian Mixture Model (GMM), the GMM having at least one class mean vector having multiple elements;

- being arranged to process the elements of the class mean vector(s) by an iterative optimisation procedure;

characterised in that the system is also arranged to scale the elements of the class mean vector(s) during the optimisation procedure to provide for the class mean vector(s) to have constant modulus at each iteration, and to normalise the data encoding vectors input to the GMM.

15. A system as claimed in claim 14 wherein the GMM has a covariance matrix, the elements of which remain constrained during the optimisation procedure such that the matrix is isotropic and diagonal, and the value of the non zero diagonal elements remain constant throughout the optimisation procedure.

16. A system as claimed in claim 14 or claim 15 wherein prior class probabilities associated with the GMM are constrained to be equal, and to remain unchanged throughout the optimisation procedure.

17. A system as claimed in any of the claims 14 to 16 wherein the data encoding vectors are normalised such that the vectors have equal moduli.

18. A system as claimed in claim 17 wherein the modulus of each data encoding vector is independent of the overall spectral power in the vector.

19. A system as claimed in claim 17 or claim 18 wherein elements forming spectral coefficients of a data encoding vector are arranged to be individually proportional to the square root of the power in their corresponding spectral band divided by the square root of the overall power contained in spectral bands represented in the vector.

20. A system as claimed in any of claims 17 to 19 wherein the system is arranged to add at least one additional element to each data encoding vector, wherein the added element(s) encode the overall power contained in spectral bands represented in the vector.

21. A system as claimed in claim 20 wherein the system is arranged to add two elements to each data encoding vector to represent the overall power in spectral bands, these two elements arranged such that the sum of their squares is a constant across all data encoding vectors that represent the spectrum of the input signal.

22. A system as claimed in any of claims 14 to 21 wherein the derivation of the data encoding vectors from the input signal involves the use of a second, low level GMM, whereby this second GMM provides the data encoding vectors to the original GMM that comprise elements derived from the second GMM's posterior probabilities.

23. A system as claimed in claim 22 wherein elements of the data encoding vectors input from the second GMM to the original GMM are proportional to the square root of posterior probabilities of the second GMM.

24. A system as claimed in claim 22 wherein elements of the data encoding vectors input from the second GMM to the original GMM are proportional to posterior probabilities of the second GMM.

25. A system as claimed in any of claims 22 to 24 wherein the constant values for the modulus of each of the class mean vectors may be different at each level.

26. A method of processing a signal, the signal comprising a plurality of multi-element data encoding vectors, wherein the data encoding vectors are derived from an analogue or digital input, and where the method employs at least one Gaussian Mixture Model (GMM) or GMM based Hidden Markov Model (HMM), the GMM or GMM based HMM having at least one class mean vector having multiple elements, and the elements of the class mean vector(s) are optimised in an iterative procedure, characterised in that the elements of the class mean vectors are scaled during the optimisation procedure such that the class mean vectors have a constant modulus at each iteration, and the data encoding vectors input to the GMM or GMM based HMM are processed such that they are normalised.

27. A method as claimed in claim 26 wherein a covariance matrix within the GMM or GMM based HMM has one or more elements, all of which are constrained during the optimisation procedure such that the matrix is isotropic and diagonal, and the value of its non zero elements remain constant throughout the optimisation procedure.

28. A method as claimed in claim 26 or claim 27 wherein prior class probabilities associated with the GMM or GMM based HMM are constrained to be equal, and to remain unchanged throughout the optimisation procedure.

29. A method as claimed in any of claims 26 to 28 wherein the data encoding vectors are scaled in a pre-processing stage before being input to the GMM or GMM based HMM, such that the moduli of all data encoding vectors are equal.

30. A method as claimed in claim 29 wherein the modulus of each data encoding vector is independent of the overall power in the vector.

31. A method as claimed in claim 29 or claim 30 wherein elements forming spectral coefficients of a data encoding vector are arranged to be individually proportional to the square root of the power in their corresponding spectral

band, divided by the square root of the overall power contained in spectral bands represented in the vector.

32. A method as claimed in any of claims 29 to 31 wherein at least one additional element is added to each data encoding vector, wherein the added element(s) encode the overall power contained in spectral bands represented in the vector.

33. A method as claimed in claim 32 wherein two elements are added to each data encoding vector to represent the overall power in spectral bands, these two elements arranged such that the sum of their squares is a constant across all input vectors that represent the spectrum of the input signal.

34. A method as claimed in any of claims 26 to 33 wherein the GMM or GMM based HMM provides the observation probabilities for a higher level HMM.

35. A method as claimed in any of claims 26 to 34 wherein the derivation of the data encoding vectors from the input signal involves the use of a low level GMM, whereby this low level GMM provides the data encoding vectors to the GMM or GMM based HMM that comprise elements derived from the low level GMM's posterior probabilities.

36. A method as claimed in claim 35 wherein elements of the data encoding vectors input from the low level GMM to the GMM or GMM based HMM are proportional to the square root of posterior probabilities of the low level GMM.

37. A method as claimed in claim 35 wherein elements of the data encoding vectors input from the low level GMM to the GMM or GMM based HMM are proportional to posterior probabilities of the low level GMM.

38. A method as claimed in any of claims 34 to 37 wherein the constant values for the modulus of each of the class mean vectors may be different at each level.

39. A signal processing system that has been trained according to the method as described in claim any of claims 26 to 38.

40. A computer program designed to run on a computer and arranged to implement a signal processing system for processing one or more multi-element input vectors, the system:

- having means for deriving the data encoding vectors from input signals;
- being arranged to process the data encoding vectors using a at least one of a Gaussian Mixture Model (GMM) and a GMM based Hidden Markov Model (HMM), the GMM or GMM based HMM having at least one class mean vector having multiple elements;
- being arranged to process the elements of the class mean vector(s) by an iterative optimisation procedure;

characterised in that the system is also arranged to scale the elements of the class mean vector(s) during the optimisation procedure to provide for the class mean vector(s) to have constant modulus at each iteration, and to normalise the data encoding vectors input to the GMM or GMM based HMM.

41. A speech recogniser incorporating a signal processing system for processing one or more multi-element input vectors, the recogniser:

- having means for deriving the data encoding vectors from input signals;
- being arranged to process the data encoding vectors using at least one of a Gaussian Mixture Model (GMM) and a GMM based Hidden Markov Model (HMM), the GMM or GMM based HMM having at least one class mean vector having multiple elements;
- being arranged to process the elements of the class mean vector(s) by an iterative optimisation procedure;

characterised in that the system is also arranged to scale the elements of the class mean vector(s) during the optimisation procedure to provide for the class mean vector(s) to have constant modulus at each iteration, and to normalise the data encoding vectors input to the GMM or GMM based HMM.